Sep 79

Micro Consultants Ltd

INTELLECT

- An Intelligent Television System for the Electronic Processing and Generation of Pictures
- Real-Time Picture Capture, Storage and Display at 15MHz
- Full 512 x 512 Resolution with 256 Luminance Levels
- Interactive Computer-Controlled Picture Processing
- TV, IR, X-Ray, Radar and Sonogram Applications for Cartesian, Polar or Line-Scan Images
- 'ART' - a High Power Picture Processing Executive Language

INTELLECT

A new dimension in Image Processing and Synthesis

WHY INTELLECT ?

The manipulation of pictures by digital methods is finding increasing application in many diverse fields ranging from broadcast television, infra-red imaging and military image processing to medical electronics, sonogram displays and pattern generation equipment for commercial artists.

Although it has long been acknowledged that digital techniques have much to offer, particularly where flexibility is important, the implementation and optimisation of the appropriate function on anything but a theoretical basis is often a tedious and cumbersome task.

Even small changes in special purpose hardware are difficult and expensive to undertake and, whilst the digital computer has been available to make light work of the computational aspects, the peripheral equipment, necessary for entering images as data into the computer and for displaying the computed results, has not been so readily available. Those pieces of equipment that have been built tend to be slow or inflexible and frequently limit the quality of the picture.

What has long been needed is an interactive, intelligent system that has the ability to capture and process large quantities of data quickly, as well as display the results in real-time as the computation proceeds. Furthermore, these acquisition and display media must perform their function without degrading the quality of the original image.

Such equipment would make a significant contribution to the interactive design function, since those users associated with image analysis or processing could enter a picture, choose an algorithm, and then observe the result in a matter of seconds. Those users associated with image synthesis could observe the picture at full resolution as it is created.

It is against this background that the concept of INTELLECT was devised. INTELLECT is an intelligent television system for the electronic generation and processing of pictures and, for the first time, gives the designer interaction with his machine. In real-time, a frame of video may now be captured, displayed and interfaced to a computer. The resolution of the system, both spatial and grey tone, has been matched to that of conventional television, thus ensuring no degradation of the picture. The operator is free to process the captured frame in many different ways by merely changing the computer program whilst observing the results on a flicker-free TV screen.

INTELLECT is equally applicable in the field of synthetic pictures. These may be drawn by the computer, as in the case of pattern generation and graphics applications, or derived from an alternative source of signal, as in the case of spectrum analysis or radar processing.

The equipment has also been designed with the hardware engineer in mind, since facilities have been included for adding hardware processing to the video paths. Hybrid functions, simultaneously combining both hardware and software processing, are also possible.

Micro Consultants Limited have developed a new programming language to complement INTELLECT. This language, known as 'ART', is a high level operating system capable of allowing users, not familiar with programming, to fully utilise the interactive capabilities of the machine.

INTELLECT, therefore, whether as a research tool or as an item of processing equipment in its own right, offers a new dimension to those customers who process, analyse, draw or synthesise images across the spectrum, from X-rays to sound waves.

WHY MICRO CONSULTANTS ?

Micro Consultants Limited are forerunners in the fields of digital video processing and computerised data handling systems. The Company was the first to market systems capable of digitising colour television signals and reconstituting the picture without degradation. Micro Consultants digital video equipment is now sold throughout the world for applications ranging from broadcast television and infra-red cameras to medical electronics and radar systems.

The Queen's Award to Industry for Technical Innovation was awarded to the Company for their products in this area during 1975.

The Company number amongst their staff acknowledged experts in the world of digital video processing, computerised data handling systems and software language development. This expertise made inevitable the marriage between the high speed video processing equipment and the minicomputer. The result of this collaboration has been INTELLECT, the worlds first truly interactive, real-time, image processing equipment.

Photograph of an Image "Captured" by INTELLECT

TECHNICAL DESCRIPTION

INTELLECT essentially comprises a digital video frame store, a high speed video input, a high speed video output, a mini computer and a hardware interface. The video input can capture, in real-time, a frame of incoming video whilst the video output is able to continually reproduce the contents of the store in raster format at standard television rates for display on a conventional monitor. The mini-computer can modify or analyse at will the contents of the store under software control and the hardware interface may ultimately replace the computer software with hardware.

The System

The system is centered around the video frame store which is able to hold two fields of 256 lines, each line containing 512 picture points. The frame store is so arranged that it can accept video at up to 15 MHz sampling frequency and reproduce it for display at the same rate. The reading and writing processes for the store are independent, can operate simultaneously and may also be completely asynchronous. The mini-computer has direct access to any picture point in the store and may either read information from the frame store, write information to it, or alternatively, remove data from the picture, modify it and replace it. The contents of the store may, at any time, be displayed on the TV monitor by the operator.

Figure 1 shows a block schematic diagram of the system. The incoming video is fed to a sync separator which is able to activate the store write address control circuit for video generated by either a normal camera source or a tape recorder. The video is then digitised into an 8 bit word by a video analogue to digital convertor.

This digitised video signal is then passed through a processing stage where the computer adjusts the bit length of the word to be used and also determines if the entire frame is to be stored. Following this processing stage the digital video is made available at line drivers, in order that hardware, utilising the frame store, may be added when required. In the absence of this special processing unit the video is linked directly into the input of the frame store.

The digital video, now held in the frame store, is read continuously to an output processing facility which, under computer control, selects the field to be displayed, the number of bits to be used, and the positioning of cross-wires etc. This processing is followed by a video digital-to-analogue converter and a processing amplifier to generate composite video for display on a conventional TV monitor.

The read circuits are all controlled by a sync pulse generator which not only creates a composite sync waveform but also sets up the appropriate read address circuits. A separate path is available for feeding back the digital video output from the store to the hardware processing facility on the input.

The input and output sections of the system are completely asynchronous and require no phase or frequency locking, except upon implementation of certain hardware processing functions requiring the output of the store to be connected to the input.

Whilst the video input and output paths for the store are essentially raster type functions, the computer has random access to the store and may address any picture point at will. The data, transferring from the store to the computer or vice versa, is buffered in such a way that this path too may be asynchronous with respect to the video lines.

Any standard computer peripheral may be attached to the I/O buses available on the machine.

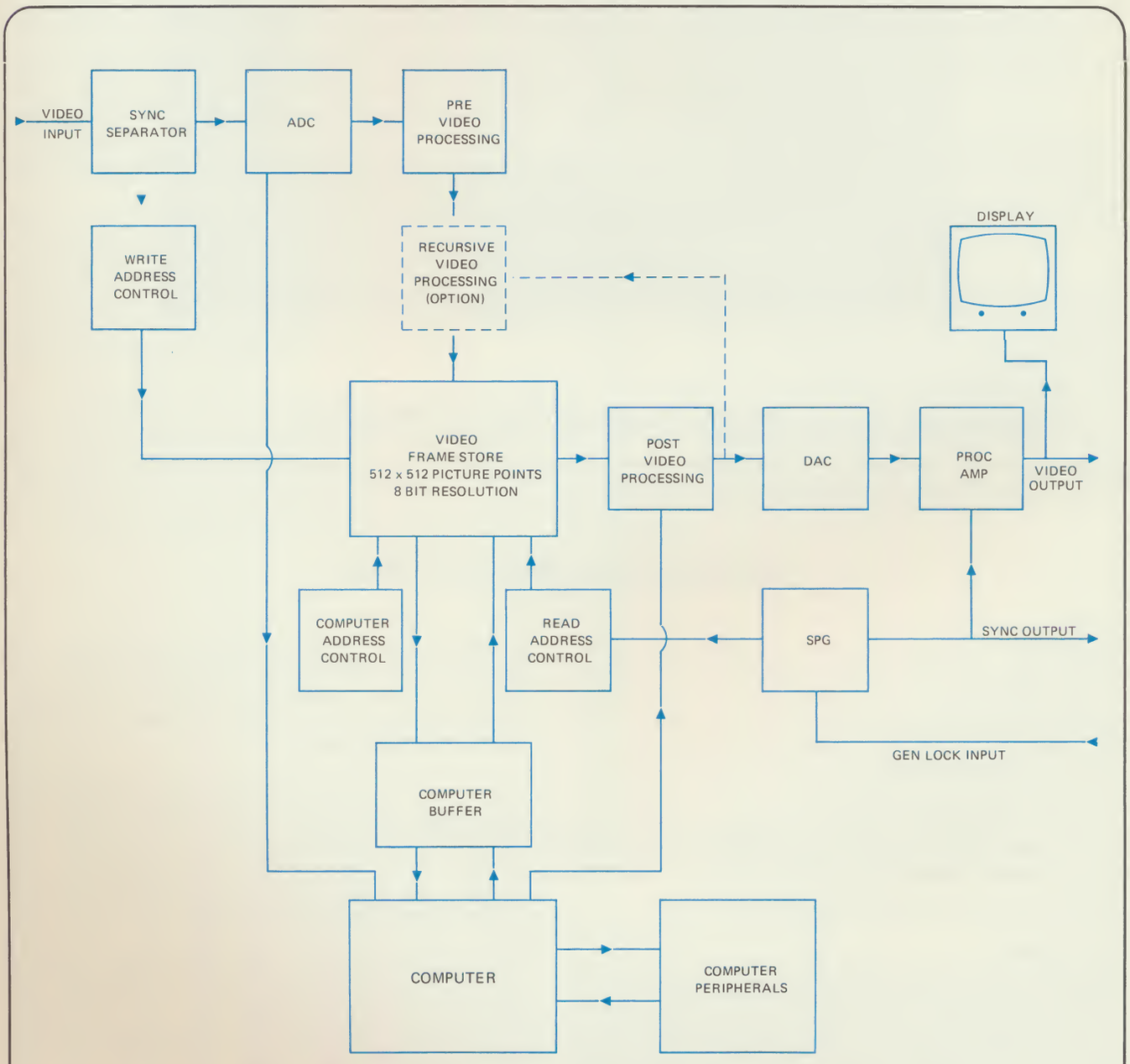


FIG.1 INTELLECT Block Schematic Diagram

Video Input

The high speed video input port of INTELLECT accepts information which is basically raster in format. The asynchronous nature of the system allows operation over a very wide range of frame rates, from standard television through slow scan systems, such as electron microscopes, to line scan imagers, such as IRLS or SLAR.

The sync separator, supplied as standard with INTELLECT, accepts conventional composite video from any normal CCTV camera, video tape recorder or broadcast source. However, many other types of input may readily be used with the addition of an interface to indicate start of line, start of frame etc.

The maximum input sampling rate is 15 MHz and the video is digitised into 8 bits giving 256 possible shades of grey.

Non raster type formats such as spiral and polar scans may be entered into the system, via the computer, with a suitable interface, although this process is somewhat slower than the video input port. For those customers not requiring the high speed video input facility, INTELLECT may be supplied without this input stage.

The Frame Store

The frame store is constructed with the 4096 bit N-channel dynamic RAM chip which has now become the industry standard for new generation semi-conductor memories. This element enables the physical size of the store to be considerably reduced in comparison to previous technologies and this, in turn, eases the design of the store architecture for video systems.

The frame store is arranged as two fields of 256 by 512 words, 8 bits wide in order that 512 video lines, each containing 512 picture points, may be held in memory.

Since the 4096 bit RAM chip is relatively slow in its operation, internal demultiplexing is necessary to reduce the speed requirement for any individual chip. However, as far as the user is concerned, the external addressing system is that of a conventional array. A 9 bit binary address defines the line in the picture and another 9 bit address defines the picture point within the line.

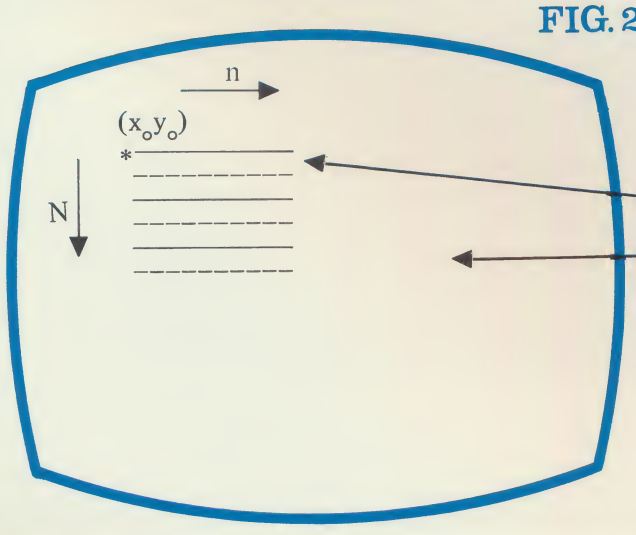
The system has the facility that the programmer will be able to address areas of the frame store by merely identifying the top left hand corner of the rectangle and the length of the two sides, as shown in figure 2.

The reading process from the store to the display is uninterrupted by any computer demands and uses a separate address register which the computer is normally unable to modify. For the purpose of reading from the frame store to the display and writing from the television input port to the store, the access time of the memory is 67 nanoseconds, thereby enabling a standard television picture to be easily accommodated from the 512 samples in a line. However, for random access by computer, the transfer rate varies depending upon whether an array is being addressed or whether individual random picture points are to be accessed. For the raster type transfer, the word rate is normally limited by the computer to approximately 730 kHz. For the truly random operation the computer limits this figure still further, since a new address has to be derived for each picture point in turn.

The store has the facility of being 'bit selectable', which means that the operator may choose which part of the 8 bit word he wishes the computer to write into or read from. Similarly, the input and output channels may be controlled to use a different selection of 'bits' - from the full 8 bit word down to single bit operation. In this way, different and unrelated pictures may be held in the respective sections of the 8 bit word. Alternatively, part of the word may be reserved for superimposing the computer output onto an original picture stored at, say, six bit level.

Two modes of interlace are available from the store; firstly, normal 2 to 1 interlace where each field of the store is read alternately; secondly, a 2 to 1 interlace where the odd fields are repeated in the even display field or vice versa. Using this second mode the programmer may store two different pictures in the two fields.

FIG. 2 Array Addressing by Computer



odd field data
even field data

Rectangle to be addressed by computer

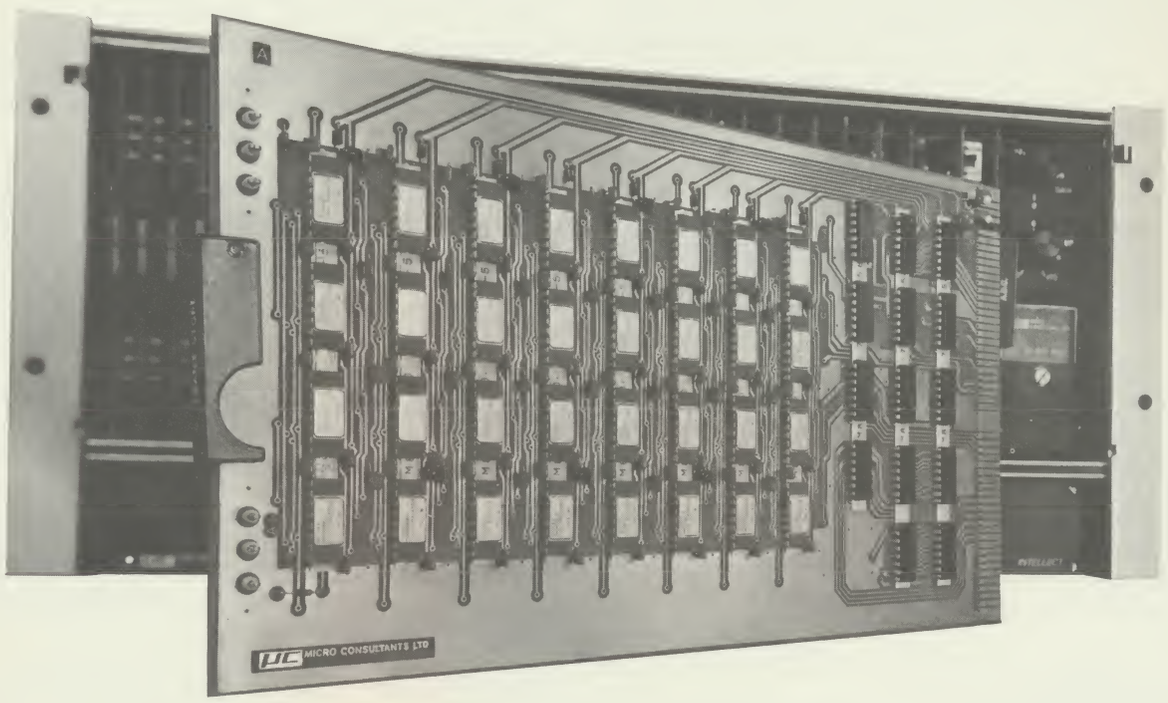
Captured picture

Locations accessed are:

$(x_o,y_o), (x_o + 1,y_o) \ldots\ldots\ldots (x_o + n,y_o)$

$(x_o,y_o + 1), (x_o + 1,y_o + 1) \ldots\ldots (x_o + n,y_o + 1)$

$(x_o,y_o + N), (x_o + 1,y_o + N) \ldots\ldots (x_o + n,y_o + N)$



INTELLECT Frame Store Card containing 131,072 bits

The Computer

The system is normally supplied with a Computer Automation Alpha LS1-2 mini-computer. This family of mini-computers is highly flexible and easy to program using assembler language. Organisation of the CPU enables the computer to obtain a high memory efficiency and the I/O structure is simple and efficient, thus reducing the difficulty of interfacing either standard or non-standard peripherals to the CPU.

However, Micro Consultants have considerable experience in interfacing systems to all types of mini-computers including DEC, Honeywell, Hewlett Packard and Data General machines. Indeed, the Company have, at their development laboratories in Newbury, a large number of computers for development purposes. INTELLECT may therefore be supplied for operation with the majority of mini-computers.

Transfer of data between the mini-computer and INTELLECT is via a bi-directional link capable of working at a rate compatible with the frame store.

The standard I/O bus transfer is concerned with setting up picture areas and the truly random address mode operation. Furthermore, the I/O section passes data for controlling various other modes of the machine, including bit select, type of interlace, acceptance of new frame of video, which field is to be used etc.

Since INTELLECT uses a standard mini-computer, the complete range of normal computer peripherals may be added if required. These include tape decks (both reel to reel and cartridge), line printers, graph plotters, touch tablets, VDU's, teletypes etc. For users needing the facilities of a large computer INTELLECT may be interfaced, via its mini-computer, to the large machine. The mini-computer then is acting as a systems manager for INTELLECT, passing appropriate data to the main frame for processing.

The Hardware Interface

Facilities have been included for adding hardware processing to the video paths. Three ports are available to the hardware engineer; the output from the store, the input to the store and the digital video entering the system. All the data is presented on line drivers or receivers at a socket panel at the rear of the unit. The system is timed in such a way that, providing INTELLECT is being run synchronously, all the words presented at the hardware interface at any one time are associated with the same position in the frame. The hardware processing functions may be added by the customer himself, or alternatively, Micro Consultants' Video Systems Department will be pleased to undertake such work.

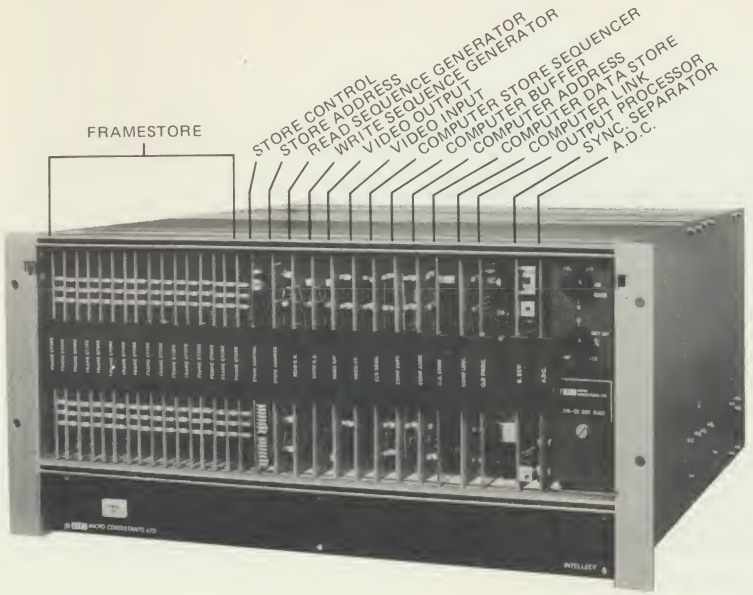
The Video Output

The output from the system is normal composite video to conventional 525 line format. The sync is mixed after the video has been reconstituted to analogue form in order that the programmer has available the full dynamic range of the 8 bit word for display. A composite sync waveform is also produced for those users requiring separate sync operation. 625 line format systems are available as an option.

Store Failure Protection Circuit

In the most unlikely event of the failure of a store element the operator may, by removing the front panel, operate a switch which will remove the effect of the element in question. This is achieved by incorporating interpolation circuits to substitute information from the adjacent picture-points. The facility is extended to include an entire store card if removed for servicing.

Photograph of an Image Generated by INTELLECT



INTELLECT with front panel removed

SYSTEM OPTIONS

Crosswires
As an alternative to generating crosswires by software with 'ART', a hardware crosswire facility is available, controlled via the computer. These crosswires are mixed onto the video after the store and do not corrupt store data.

Window Selection
The operator has the facility of selecting a limited area, or 'window' of the incoming video to be stored, without overwriting information held in memory outside this window area.

This facility is similar to the inset technique normally used in television production. The window is specified by indicating, via the computer, the co-ordinates of the top left and bottom right corners of the rectangle required. This area is then designated as either the portion of the picture to be written into store or as the portion of store to be protected, with the remainder of the picture being entered in memory.

A similar facility is available on the output circuits of INTELLECT. A portion of picture may be selected for display with all areas outside the chosen rectangle set to some predetermined grey level.

Hardware Picture Scroll
The Programmer is able to shift the origin of the picture being displayed, by any number of picture points. If the computer defines the offset of the normal origin of the picture (the top left hand corner) the display will, on the next frame, restart with the origin apparently shifted. Information lost on one side of the display by this shift will reappear on the opposite side.

Interlace Selection
Three modes of interlace are available. Firstly, the normal 2 to 1 interlace, reading each field in the store alternately; secondly, a 2 to 1 interlace but repeating either the odd store field in the even display field or vice versa; and thirdly, a special form of display where the two fields on the display are placed on top of each other; these two fields may be either the odd field repeated, the even field repeated or both interlace fields of the stored frame.

Video Inversion (Negation)
The output video may be inverted to display input blacks as whites and input whites as blacks. This is particularly useful for infra-red applications.

Picture Inversion
The origin for the input picture may be moved to the bottom left hand corner of the display having the effect of turning the scene upside down. Alternatively, this facility may be used to enter line scan video from either the bottom or the top of the frame.

Partial Colour
A standard 8-bit system may be adapted to produce RGB colour by allocating some of the 8-bits in the video word to chrominance. For example, the word may be split so that five bits are used for luminance and three for chrominance. This would give the choice of eight colours for each picture point. An additional option allows the computer to change this selection of eight different colours on a frame-by-frame basis. In this way the entire hue triangle is available to the programmer with only an 8-bit system.

Full Colour
The system may be expanded to produce full RGB colour by addition of another two frame stores. Colour pictures may be either entered into the system on a frame sequential basis, or alternatively, three input video ports may be provided. All the facilities of monochrome INTELLECT may be extended to the colour version.

Multiple Inputs
Multiple input ports may be supplied which enable asynchronous video sources to share the one common synchronous display.

Gen-locking
The output video may be locked to station syncs for studio work or applications involving multiple video sources requiring a common sync source.

HIGH LEVEL LANGUAGE 'ART'

In order to make INTELLECT a powerful system in the hands of both programmers and engineers, a special high level language for image analysis and synthetic picture generation has been written. The language, designated 'ART', runs on the Alpha LSI-2 computer, which is normally part of the INTELLECT system.

No existing language has the speed of operation necessary for execution in the interactive form of picture processing. ART is capable of processing an entire frame of video in a time scale of seconds and to process sections of the frame in real time on the frame by frame basis.

During the specification of ART two aspects were considered of paramount importance. Firstly, the speed of execution, and secondly, the ease and flexibility of use by engineers, operators and professional users not closely associated with programming.

The first objective has been achieved by the use of single word length arithmetic on a computer equipped as standard with hardware multiply and divide instructions, thus ensuring that the object code is in a highly optimised form.

The second objective was achieved by using a notation similar to FORTRAN and numbering each line of stored program for easy listing and modification in a way resembling BASIC.

In use, each line is entered from the VDU keyboard, is checked for correct syntax and immediately compiled. Both source and object code are stored, and, if an error is found, an appropriate diagnostic is immediately issued.

A range of standard I/O peripherals may be used with ART for numeric or character information but the language also allows the use of machine level I/O commands which, in conjunction with system commands, allow the addition of any peripheral device for data input, output or system control, without modification to the compiler.

The tasks carried out by ART programs range from the simple addition of moving cross-wires to a two dimensional transform operation on a highly complex picture. The language is particularly valuable in the development of picture processing techniques which are intended to be subsequently implemented in hardware. Many different algorithms may be tried and the results quickly observed. The use of INTELLECT in this mode optimises the algorithm and may be used to minimise the hardware design costs.

Character set and Crosswires Generated by "ART"

INTELLECT SPECIFICATION

VIDEO INPUT PORT

Video Input

Format		525/60 Hz Monochrome 625/50 Hz Monochrome (option) Other raster type formats to order.
Amplitude		1 volt peak to peak
Impedance		75 ohm
Return Loss		> 30 dB
Signal-to-Noise Ratio		53 dB peak signal to RMS noise
Frequency Response		±0.5 dB, DC to 4.2 MHz

Synchronising Source

Inputs		Composite Video	
	or	Composite Sync	} to order
	or	Line and Frame Drive for special input formats	
Level		4 volts peak to peak	
Impedance		75 ohm	
Input Jitter		better than 25 nanoseconds	

FRAME STORE

Maximum Sampling Frequency	15 MHz (nominal sampling frequency for conventional video operation is 10 MHz
Capacity	2, 097, 152 bits
Organisation	512 x 512 picture points x 8 bits, all picture points and bits individually selectable.
Operation	Totally Asynchronous between input, output and computer port.
Address	Top left hand corner of the display designated 0, 0 (000000000. 000000000), the bottom left 0, 511 (000000000. 111111111), the top right 511, 0 (111111111. 000000000), the bottom right 511, 511 (111111111. 111111111).
Access	Computer has random access. Access via input and output ports is essentially in raster format.

VIDEO OUTPUT PORT

Video Output

Format	525/60 Hz Monochrome 625/50 Hz Monochrome (option) RGB colour (option)
Amplitude	1 volt peak to peak
Impedance	75 ohm
Return Loss	> 30 dB
Signal to Noise Ratio	53 dB
Frequency Response	±0.5 dB, DC to 4.2 MHz

Synchronising Signals

Outputs		Composite Video
	or	Composite Sync
	or	Line and Frame Drive (to order)
Level		4 volts peak to peak
Impedance		75 ohm
Gen. Lock Input		Composite Video
	or	Composite Sync (to order)
Output Jitter when Genlocked		Better than 25 nanoseconds

COMPUTER PORT

Standard Equipment

Manufacturer	Computer Automation Inc.
Type	Alpha LSI 2/20
Word length	16 bits
Logic family	TTL - LSI
Standard Hardware provision	Power fail/restart, real-time clock, multiply, divide, normalise and autoload
Instruction time	2 microseconds for addition
Core size	8K words minimum, 32K words maximum (Frame store may be used as data store if required)
Core store cycle time	980 nanoseconds
Transfer rate of data from frame store to core	730K bytes per second
Frame store address	Random or array under program control

Configurations incorporating other manufacturer's computers to order.

Other Interfaces

DEC PDP8, PDP 11
Honeywell H 316, 516, 716
Hewlett Packard HP 2100
Data General Nova

Test and operating software is available for these machines.

SOFTWARE

On-line, interactive, real-time compiler for high level language 'ART'. Produces object code with short execution times. Optimised for image processing applications.

PHYSICAL DATA EXCLUDING COMPUTER

Size	8¾" (223mm) high, 19" (482mm) wide, 22" (559mm) deep, rack mounting unit
Weight	60 lbs. (27 kgs)
Power	115/240 volts, 50/60 Hz, 250VA
Operating Temperature Range	+ 10°C to + 35°C

A TYPICAL APPLICATION

The following INTELLECT application results from extensive research carried out by Mr. B. E. Keane, Chief Physicist of the Royal Sussex County Hospital, Brighton, England.

It has already been shown that INTELLECT, whether as a research tool or as an item of processing equipment in its own right, has a large contribution to make to those customers who process, analyse, draw or synthesise images across the spectrum from X-rays to sound waves.

Such a wide scope of applications for this new concept in picture manipulation makes it difficult to choose a typical application to give an example. However, since the field is so wide, it is important that just one use of INTELLECT should be discussed in order to demonstrate how the many facilities of the equipment relate to just one system.

Of all the many exciting applications of INTELLECT, those in the medical field in general, and in medical X-rays in particular, are perhaps the most interesting.

Conventional X-ray machines have reached a very high level of sophistication in terms of sensitivity, accuracy and manoeuvrability. However, a fundamental limit is being approached in terms of the interpretability of the resultant images, largely due to the amount of unwanted detail present in the radiograph.

This problem of unwanted detail can, to a limited extent, be overcome with the new techniques of tomography in which a scanning X-ray machine selects a particular plane or set of planes to be sharper in detail than the rest of the subject. Apart from the disadvantage that such equipment is exceedingly expensive, the whole of each selected plane tends to be equally sharp and still includes unwanted detail. Although INTELLECT has a contribution to make in the field of tomography, it finds major application with conventional X-ray equipment to process the images contained in radiographs, thereby enhancing the particular properties of interest.

Unwanted detial can take many forms and the discussion here will be limited to just two simple examples. Consider a chest film taken to examine the lungs. The ribs represent the higher spatial images with the lung detail mainly being limited to the lower spatial frequencies much as an overlaid modulation. Thus, if the ribs are removed by a high frequency spatial filter, the overlaying grey tone image of the lungs is left unimpeded. Conversely, in a lateral view of the spine, confusing changes of thickness of overlying tissue may be removed by a low frequency spatial filter, leaving a sharp outline of the vertebral bodies.

In the past, attempts to realise these filters in practice have basically failed, not because they could not be generated by analogue or optical methods for any one radiograph, but because it was impossible to have flexible yet clearly defined filters readily adaptable to the needs of a wide variety of images.

However, INTELLECT is ideally suited to this task since the necessary algorithms may now be achieved digitally by the mini-computer and a vast array of suitable filters may be held in program store.

The X-ray image is entered into INTELLECT either by a T.V. camera examining an X-ray film or directly by means of a suitable X-ray image convertor. The incoming frame of video is digitised and captured in the frame store. This picture is then displayed on the output T.V. monitor at normal T.V. flicker-free frame rates even when the input is removed. The computer then processes each picture point in the frame with the appropriate algorithm.

Using the interactive language 'ART' the various filters may be called from the program store and the improving picture may be examined on the display, although final interpretation would be left until the computer had completed the image enhancement task.

The ability of the computer to select an array for processing means that different levels of enhancement may be applied to different parts of the image.

Using the crosswire facility the operator is able to indicate the areas for different processing, either by entering coordinates on a keyboard or by using a roll ball or light pen.

If part of the picture store is needed for temporary data storage during processing, the window facility may be used to blank the appropriate part of the screen thereby leaving an uncluttered display.

If different images are required for comparison during the processing, these may be stored by using the bit selection facility or by storing separate images in the two fields.

It is clear therefore that INTELLECT is able to offer a hitherto unattainable flexibility in image enhancement to aid X-ray diagnosis.

INTELLECT

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Thank you for your interest in . . . INTELLECT

Thanks for your inquiry about our digital video product. We are enclosing the material you requested and are asking our local office to get in touch with you as soon as possible.

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Rockville, MD 20853
Attn: Dwight Wilcox
(301) 460-1454

The digital video people